::ODMA\MHODMA\IMANAGE;223070;1

Receipt
PATENT APPLICATION
Docket No.: 2037.1005-002

JMASCME dlc
05/09/01

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Peter B. Gillingham		
Application No.:	09/654,367	Group:	2818
Filed:	September 1, 2000	Examiner:	Not Known
For:	METHOD OF MULTI-LEVEL STORAGE IN DRAM AND APPARATUS THEREOF		

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to Assistant Commissioner for Patents, Washington, D.C. 20231

on 5-10-01 Deborah Celeste
Date Signature

Deborah Celeste
Typed or printed name of person signing certificate

REQUEST FOR CORRECTED FILING RECEIPT
FOR UTILITY APPLICATION

Office of Initial Patent Examination
Customer Service Center
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

We hereby request that the following items of information be corrected in the Filing Receipt for the subject application received in this office on February 8, 2001.

The errors and corrections appear below.

Continuing Data as Claimed by Applicant Section

THIS APPLICATION IS A REI of 07/916,673 07/22/1992 PAT 5,283,761

SHOULD READ AS FOLLOWS:

This is a Continuation of Reissue Application Serial No. 08/595,020 filed January 31, 1996, which is based on original U.S. Patent No. 5,283,761 issued February 1, 1994

Enclosed are a copy of the Filing Receipt with changes noted in red, and a copy of page 1 of the application as filed on September 1, 2000.

Pursuant to instructions in the February 29, 2000 O.G., we hereby request that the errors which are identified above be corrected in the captioned application to which this request for correction is directed. It is understood that the Patent Office will issue an automatically-generated, corrected Filing Receipt in this and, if applicable, any other affected applications.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By _____

Gerald M. Bluhm
Registration No.: 44,035
Telephone: (781) 861-6240
Facsimile: (781) 861-9540

Lexington, MA 02421-4799

Date: 5/9/01

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
www.uspto.gov

APPLICATION NUMBER	FILING DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	DRAWINGS	TOT CLAIMS	IND CLAIMS
09/654,367	09/01/2000	2818	690	2037.1005-002	5	10	2

21005
HAMILTON BROOK SMITH AND REYNOLDS, P.C.
TWO MILITIA DR
LEXINGTON, MA 02421-4799

FILING RECEIPT

OC000000005733449

Date Mailed: 02/05/2001

Receipt is acknowledged of this nonprovisional Patent Application. It will be considered in its order and you will be notified as to the results of the examination. Be sure to provide the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION when inquiring about this application. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Customer Service Center. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the PTO processes the reply to the Notice, the PTO will generate another Filing Receipt incorporating the requested corrections (if appropriate).**

Applicant(s)

Peter B. Gillingham, Kanata, ON CANADA;

Continuing Data as Claimed by Applicant

~~THIS APPLICATION IS A REI OF 07/916,673 07/22/1992 PAT 5,283,761~~
This is a Continuation of Reissue Application Serial No. 08/595,020, filed January 31, 1996, which is based on original U.S. Pat. No. 5,283,761 issued February 1, 1994.

Foreign Applications

If Required, Foreign Filing License Granted 02/03/2001

Title

Method of multi-level storage in DRAM and apparatus thereof

Preliminary Class

365

Data entry by : KING, DORIS **Team :** OIPE **Date:** 02/05/2001

METHOD OF MULTI-LEVEL STORAGE IN DRAM

This is a continuation of Reissue Application Ser. No. 08/595,020, filed January 31, 1996, which is based on original U.S. Pat. No. 5,283,761 issued February 1, 1994.

FIELD OF THE INVENTION

This invention relates to dynamic random access memory (DRAM) memories, and in particular to a method of storing a variable level signal in each cell of a DRAM for representing more than one bit in each cell.

BACKGROUND TO THE INVENTION

To store for example two bits in a DRAM cell, it must be able to store four different voltage levels. A problem with such cells, is that noise margins are reduced to one-third that of a one bit per cell DRAM, which is too low to withstand the occasional α-particle hit.

A second problem with multi-bit storage cells relates to the method of sensing. No simple method of sensing has previously been designed, although attempts have been made to solve this problem, e.g. as described in the publication by M. Aoki et al, "A 16-Levels/Cell Dynamic Memory", ISSCC Dig. TECH. Papers 1985, pp 246–247, and in T. Furuyama et al, "An Experimental Two-Bit/Cell Storage DRAM for Macrocell or Memory-On-Application", IEEE Journal of Solid State Circuits, Vol. 24, No. 2, pp 388–393, April 1989. The technique described by Aoki cannot use normal sense amplifiers. It requires a precision analog D to A converter to implement a staircase waveform and a charge amplifier to sense data. The technique described by Furuyama requires the generation of precision reference levels to distinguish between four levels. These levels are not self-compensated for offsets developed in the sensing operation, and this method suffers from poor signal margin. Hidaka et al describe a technique for simultaneously reading two cells at a time in the article "A divided/Shared Bitline Sensing Scheme for .64Mb DRAM Core" in the 1990 Symposium on VLSI Circuitry 1990, IEEE, p. 15, 16 which while describing dividing a bitline, is not related to multiple bit storage in a single cell.

DRAMs have previously been built with cells holding up to sixteen bits of storage, e.g. in the aforenoted article by M. Aoki et al, for use in file memories. A 4 K test array is believed to have been the largest memory built using this design. Leakage characteristics of the DRAM cell were required to be very tightly controlled and even then, accurate sensing of the small voltage differences between levels becomes very difficult. Another problem with this scheme was the length of time required to access: a single read cycle required 16 clocks for the read followed by 16 clocks for the restore.

To implement a 2 bit DRAM, one can define the cell as storing one of four voltage levels V_{cell0}, V_{cell1}, V_{cell2} and V_{cell3}, and reference voltage midpoints between these four voltage, which can be defined as V_{ref1}, V_{ref2} and V_{ref3}. These midpoints can be referred to, to differentiate between the four voltage levels. The relative voltage of these levels are shown in Table 1 below.

STORAGE VOLTAGES	REFERENCE VOLTAGES	ACTUAL VOLTAGE
V_{cell1}		V_{DD}
	V_{ref3}	5/6 V_{DD}
V_{cell2}		2/3 V_{DD}